Impact of NASA Satellite Data and Models on U.S. Coast Guard's Decision Support Tool for Search and Rescue in the Northeastern Pacific Ocean

3-Year: Sept. 2008-October. 2011 (April 2012)

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Application Partner:

Art Allen, U.S. Coast Guard (USCG)

Search And Rescue (SAR) Problem

- Create a SAR case when alerted
- Gather information about case
- Get environmental data & uncertainties
- Determine search area (knowledge, model)
- Estimate resource availability and capability
- Plan and perform the search
- Evaluate the completed search
- Repeat above until survivors are found and rescued

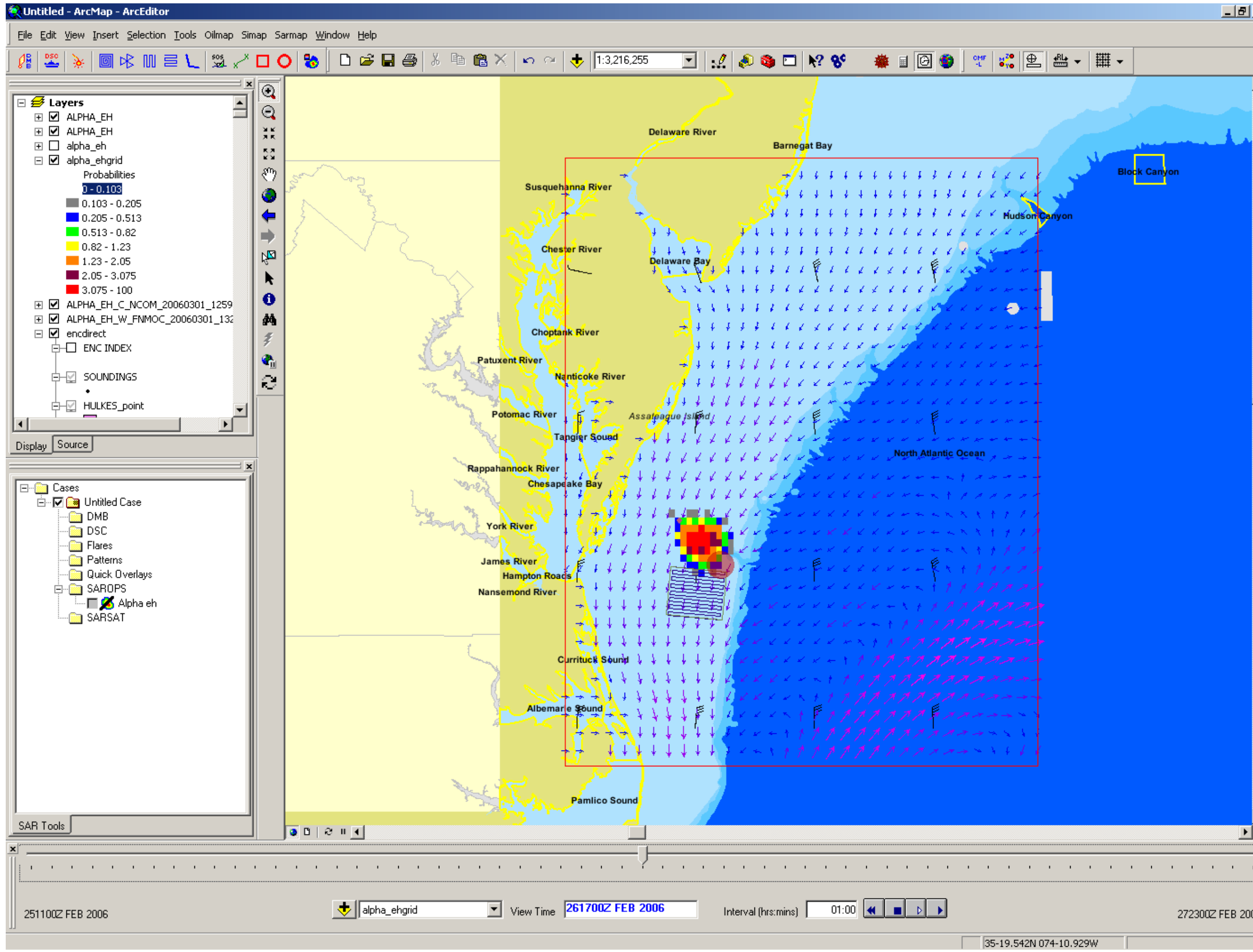
US Coast Guard (USCG) Search and Rescue (SAR) Operations Statistics

FY	Cases	Lives Saved
2005	29,780	5,648
2006	28,323	5,290
2007	27,090	5,175

Improved decision making can be quantified by lives saved

Decision Support Tool: Search and Rescue (SAR) Operations (SAROPS) by US Coast Guard and Environmental Data Server (EDS) by industry-ASA

SAROPS/EDS
Seen by the
USCG controller



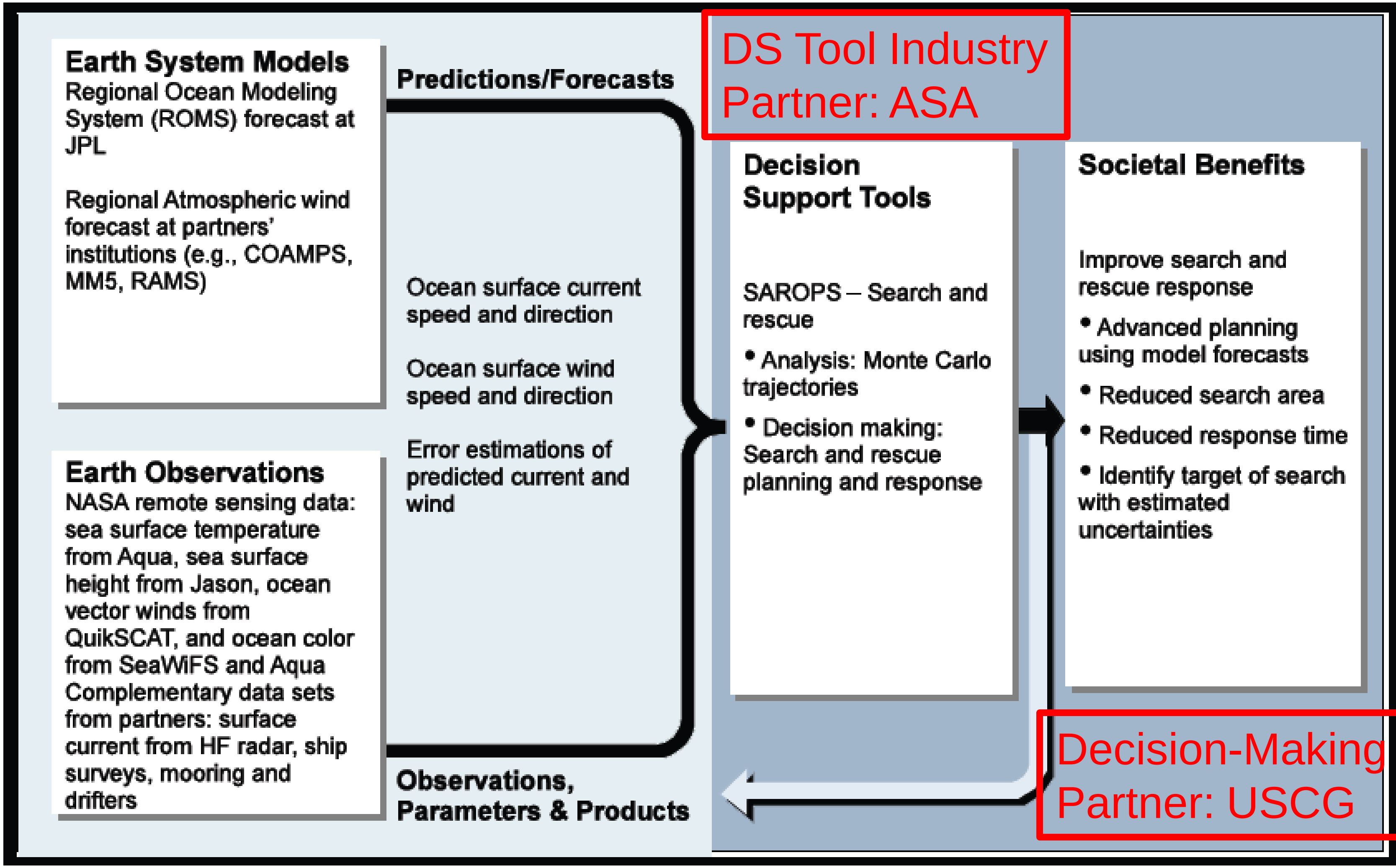
NASA Data and Model are not used, particularly off the US west coast

Data must be certified in the right place and right format

NASA Applied Science Decision Support Project Objective

- Our primary objective is to work with our U.S. Coast Guard (USCG) partner to provide improved real-time, high-resolution ocean current and wind observational data as well as ocean circulation forecasts with error estimates for inclusion in the USCG Decision Support Tool (DST) known as Search and Rescue Operations (SAROPS).

Proposed Architecture for the Search and Rescue Decision Support Tool



R&D Institutions: NASA JPL, UCSB, CU, Non-profit AOOS

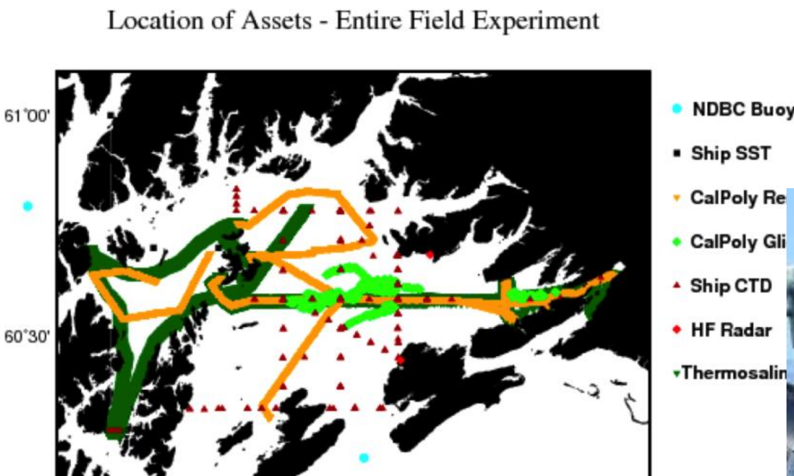
3-Year Work Plan

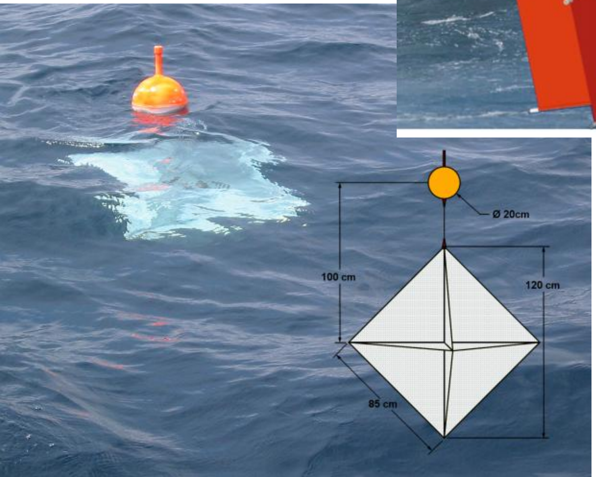
- Year 1: Establish baseline performance (benchmarking)
  - Data collection during a field experiment; Model testing and verification/validation; Benchmarking Decision Support Tool (DST)
- Year 2: Component refinement and integration
  - Understand data and model; Refine and improve the forecasting system; Explore and ultimately use new NASA satellite data
- Year 3: Quantify the improvement and Transition from research to operations
  - Data collection during another field experiment, and compare with the year 1 field experiment benchmark to quantify the improvements enabled by NASA data and model; deliver our developed data and model forecast in real-time to the decision maker (i.e., US Coast Guard) through our industry partner ASA, the designated contractor for US Coast Guard, in the right place and format; Transition from research to operations to demonstrate actual decision making with improved results (e.g., reduction of response time, reduced search areas, planning for adequate resources) and socioeconomic benefits.

Year 1: Establish baseline performance

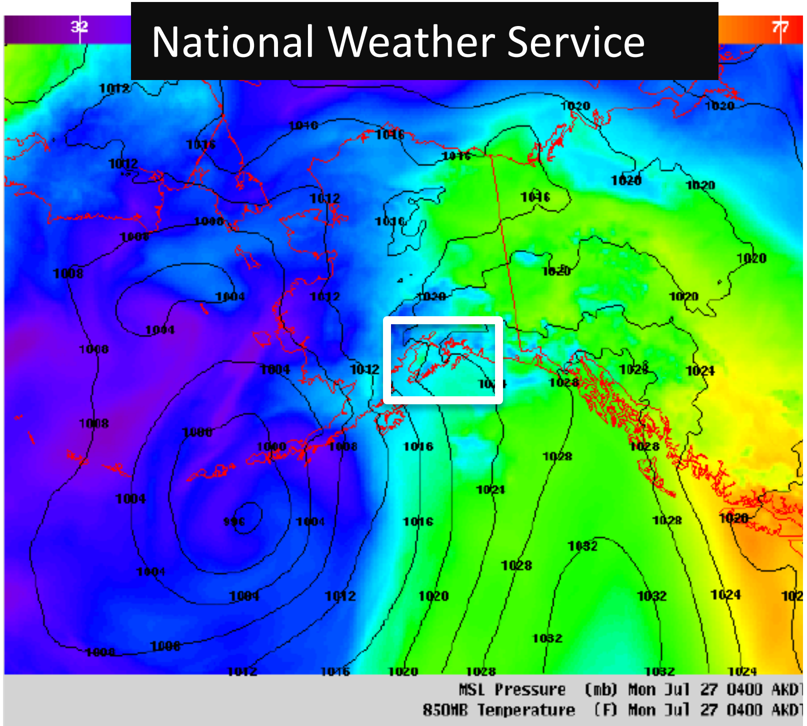
- Research & Development
  - Data collection during a field experiment
  - Model testing and verification/validation
- Benchmarking Decision Support Tool (DST)

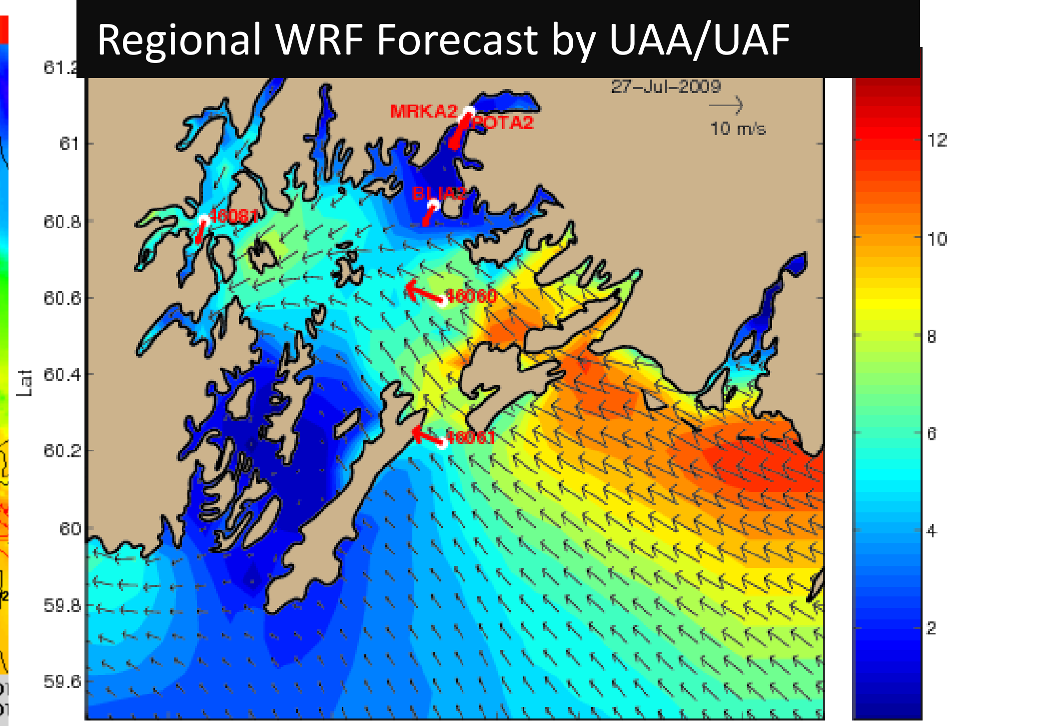
Field Experiment: July 18-Aug 3, 2009

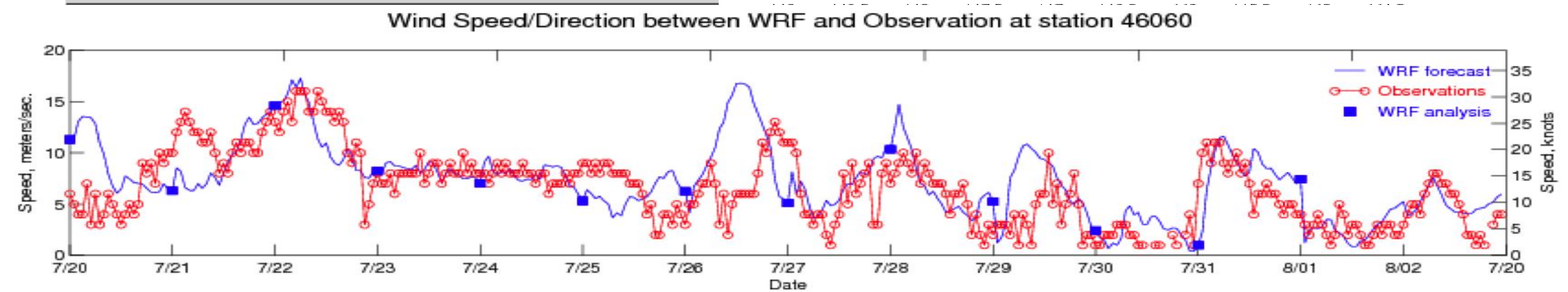


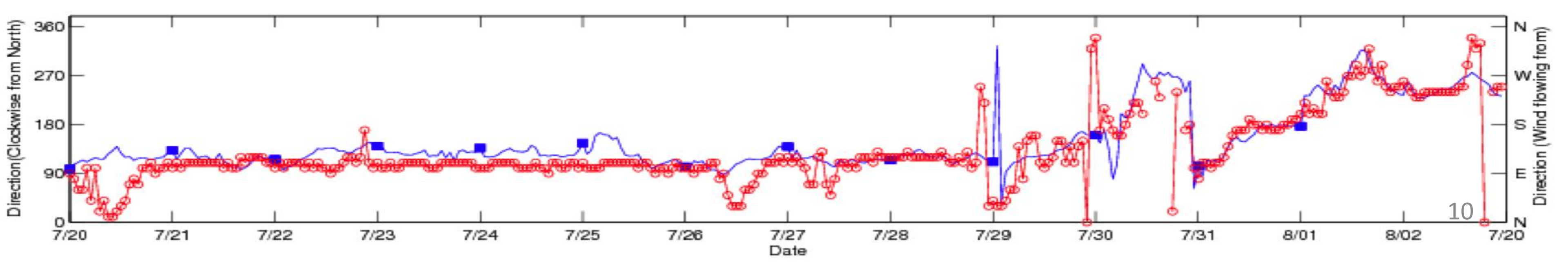


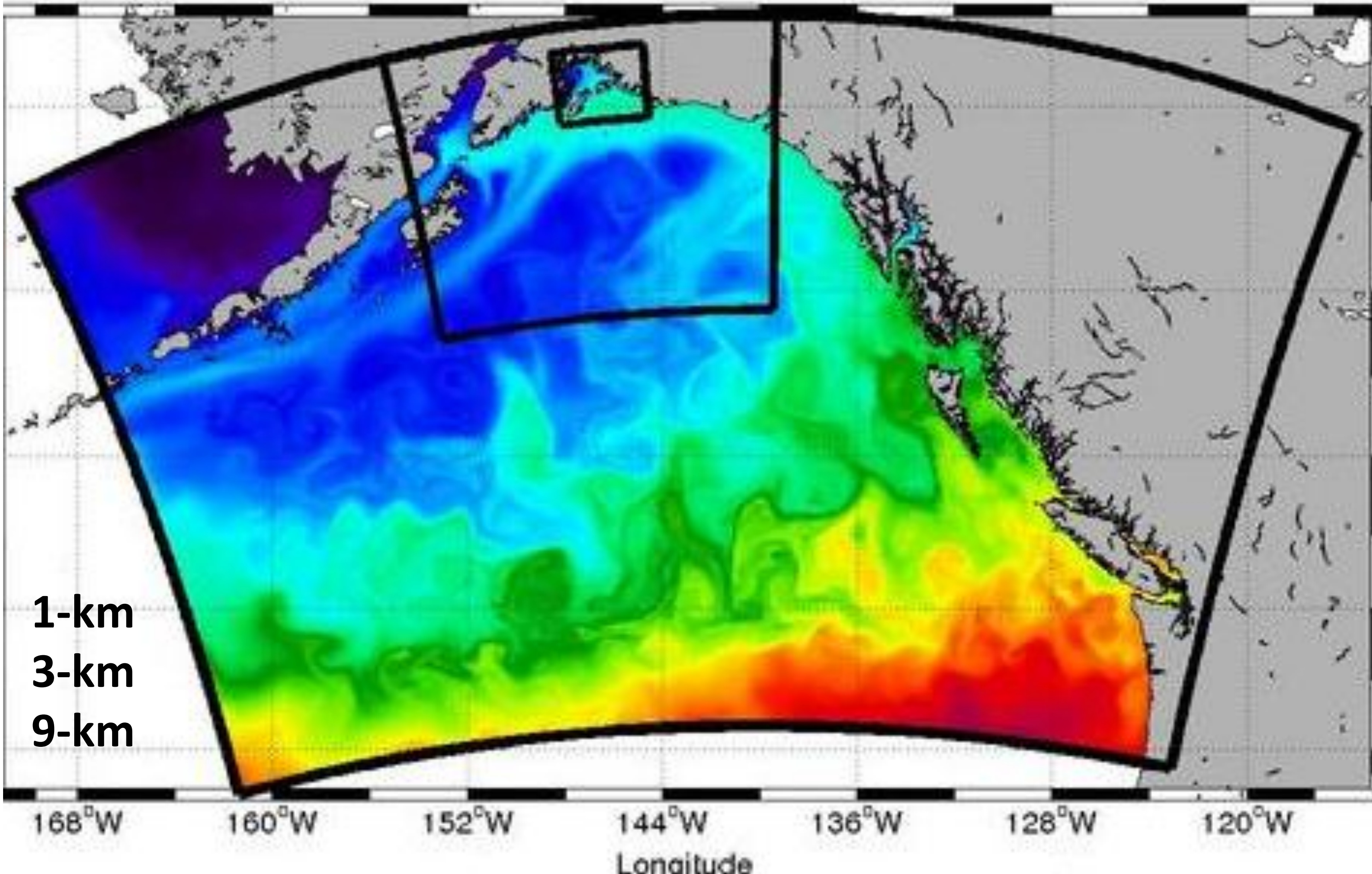
Co-sponsors: Alaska Ocean Observing System; Prince William Sound Science Center


National Weather Service
MSL Pressure (mb) Mon Jul 27 0400 AKDT
850MB Temperature (F) Mon Jul 27 0400 AKDT

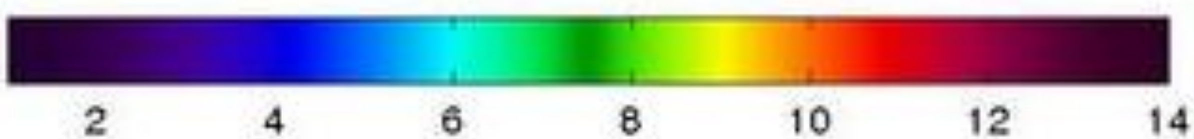

Regional WRF Forecast by UAA/UAF
27-Jul-2009
10 m/s
MRKA2
POTA2
BLIA2
46081
46060
46061
Lat


Wind Speed/Direction between WRF and Observation at station 46060
WRF forecast
Observations
WRF analysis
Speed, meters/sec.
Speed, knots
Date

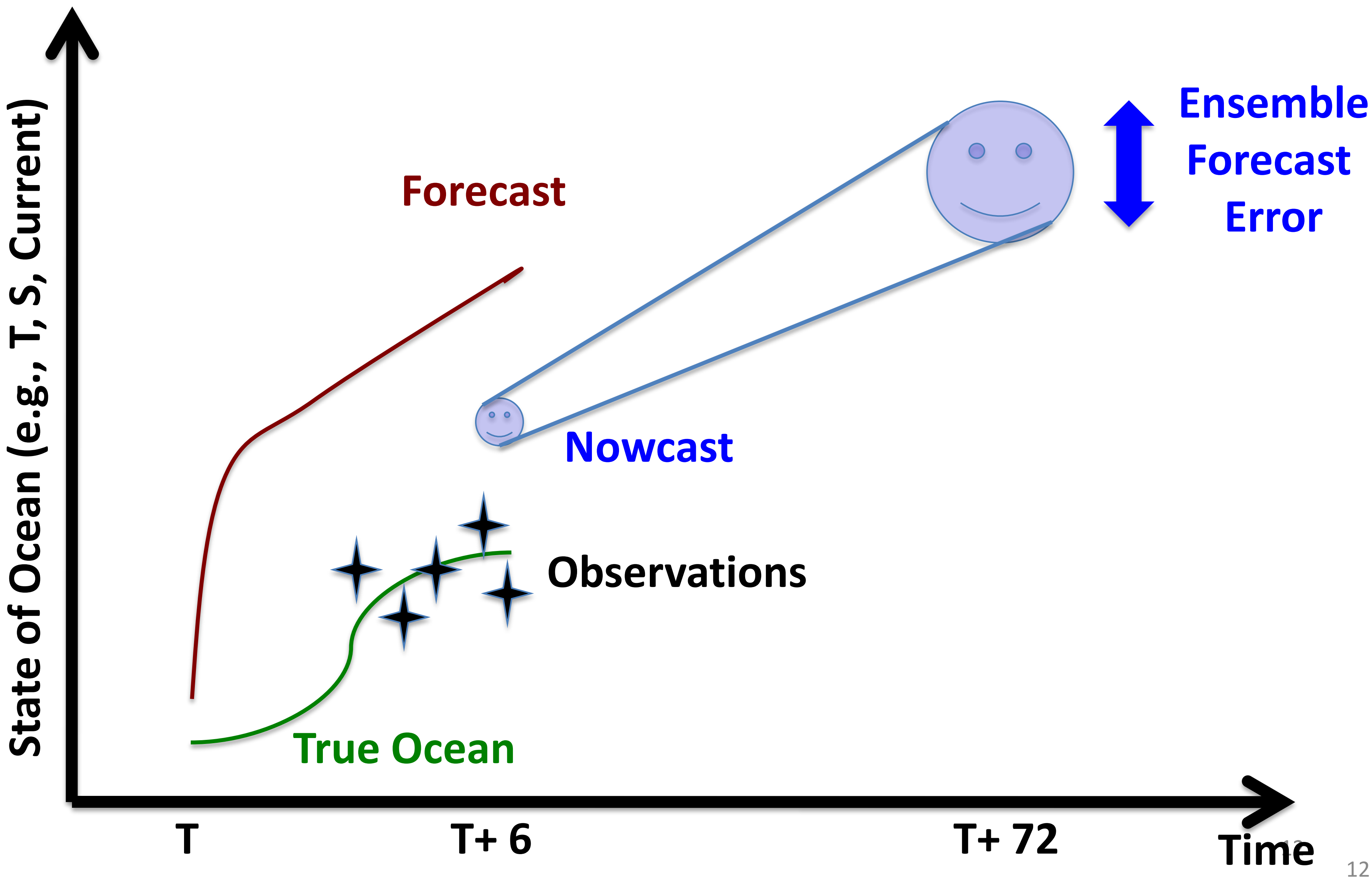

Direction(Clockwise from North)
Direction (Wind flowing from)
Date



Regional Ocean Modeling System (ROMS)



ROMS Data Assimilation to enable forecasting



3-Dimensional Variational (3DVAR) Data Assimilation

$$Min\ (J) = 0.5\ (x - x^f)^T B^{-1} (x - x^f) + 0.5\ (h\,x - y)^T R^{-1} (h\,x - y)$$

$$x^a = x^f + \delta x^f$$

y: observation

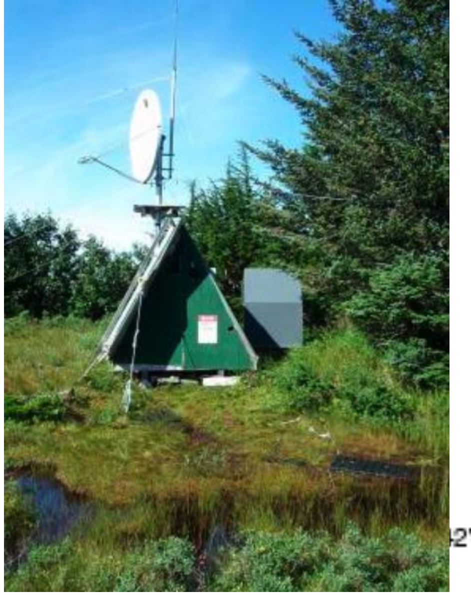
x: model

$$x = \begin{pmatrix} \varsigma \\ u \\ v \\ T \\ S \end{pmatrix} = \begin{pmatrix} x_\varsigma \\ x_{uv} \\ x_{TS} \end{pmatrix} = \begin{pmatrix} x_\varsigma^f + \Pi \delta x_{TS} + \delta x_{a\varsigma} \\ x_{uv}^f + \Gamma \delta x_{TS} + \Phi_a \delta x_{a\psi\chi} \\ x_{TS}^f + \delta x_{TS} \end{pmatrix}$$

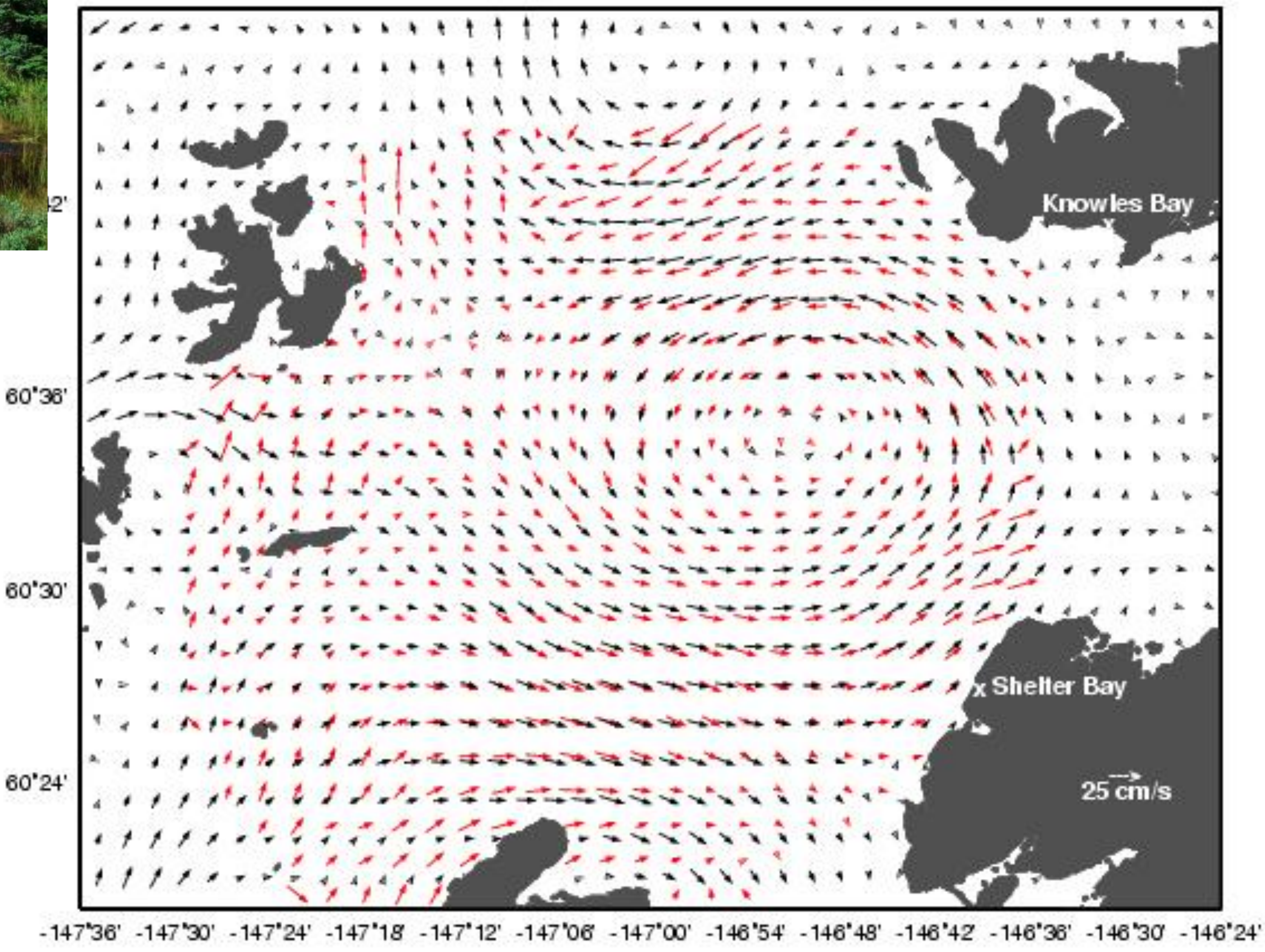
Li, Z., Y. Chao, J.C. McWilliams, and K. Ide: A Three-Dimensional Variational Data Assimilation Scheme for the Regional Ocean Modeling System. *Journal of Atmospheric and Oceanic Technology*, 25, 2074-2090, 2009.

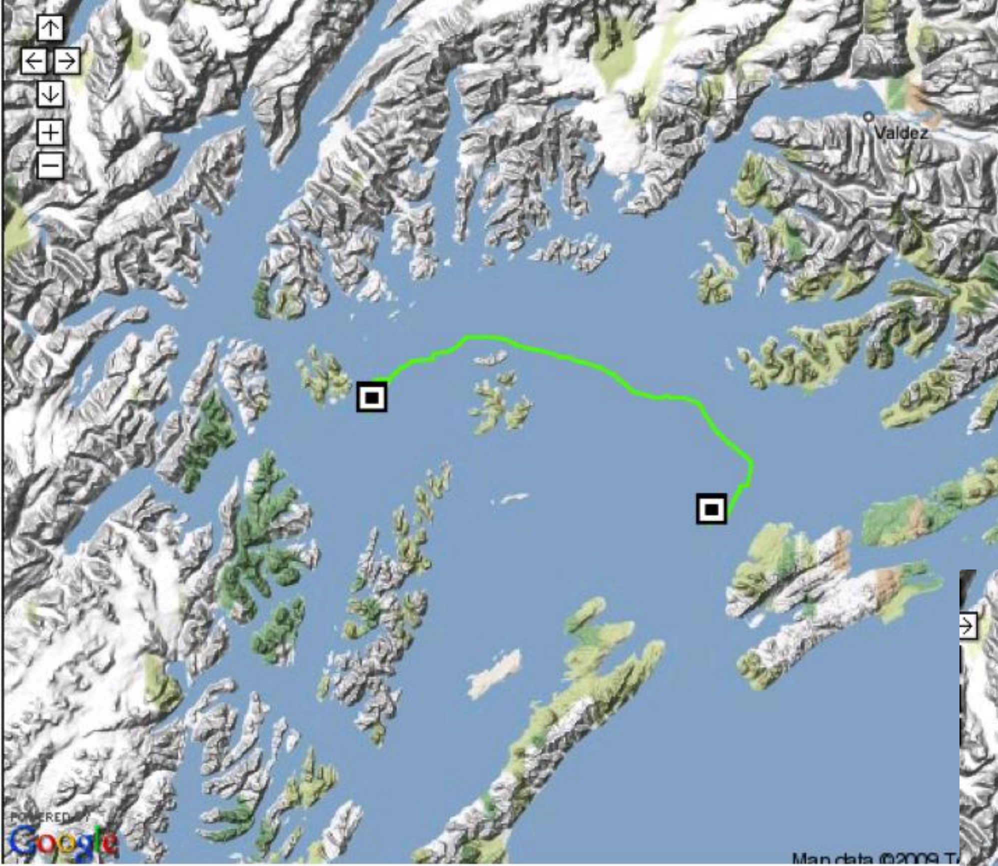
Li, Z., Y. Chao, J. C. McWilliams, and K. Ide: A three-dimensional variational data assimilation scheme for the Regional Ocean Modeling System: Implementation and basic experiments. *Journal of Geophysical Research (Oceans)*, 113, C05002, doi:10.1029/2006JC004042, 2008.

Model Verification

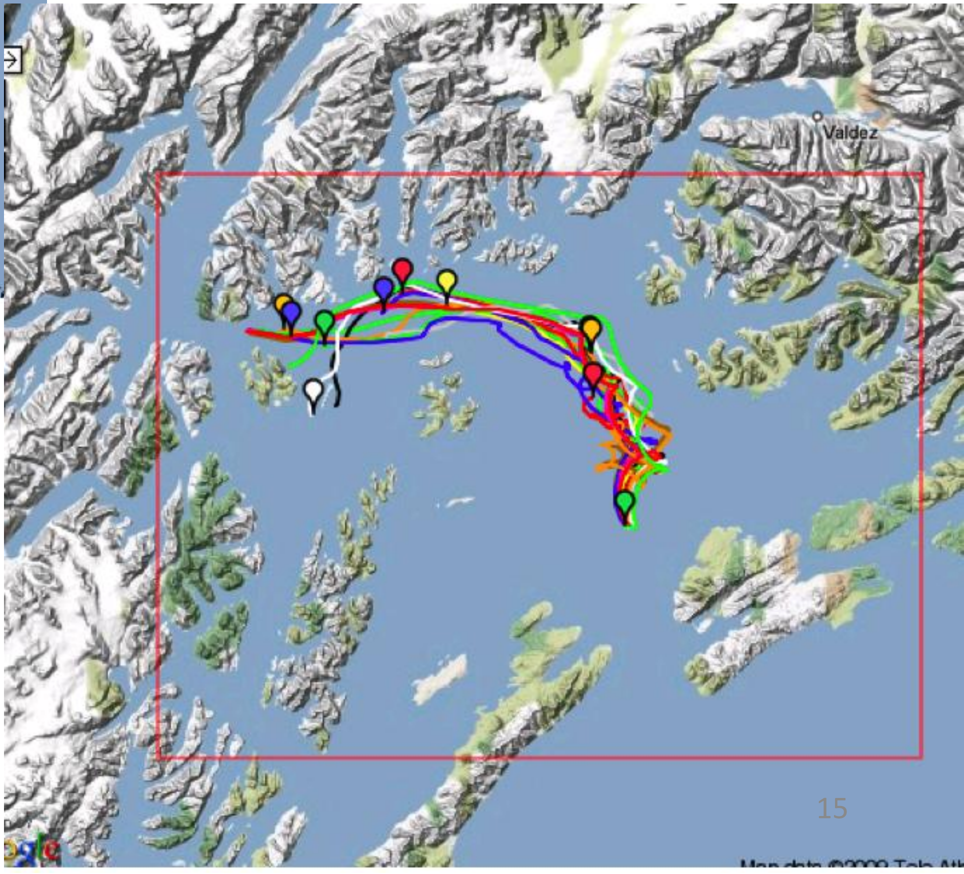


HF radar observed Mean Surface Current Vectors, July 31 - Aug 3, 2009

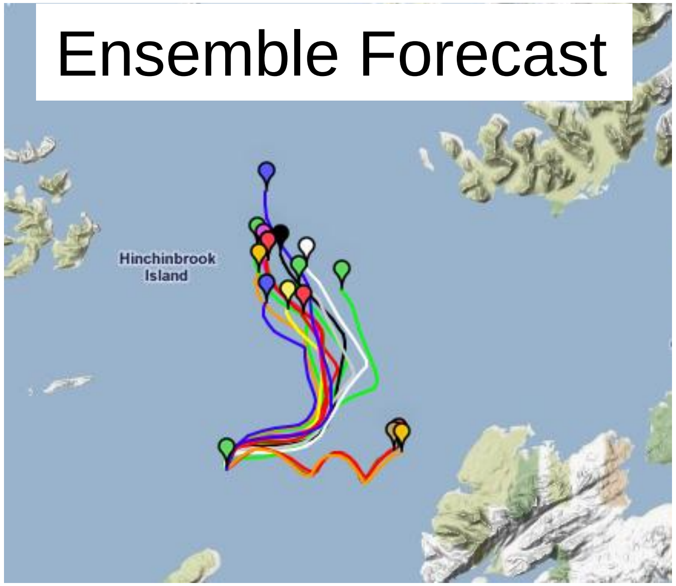


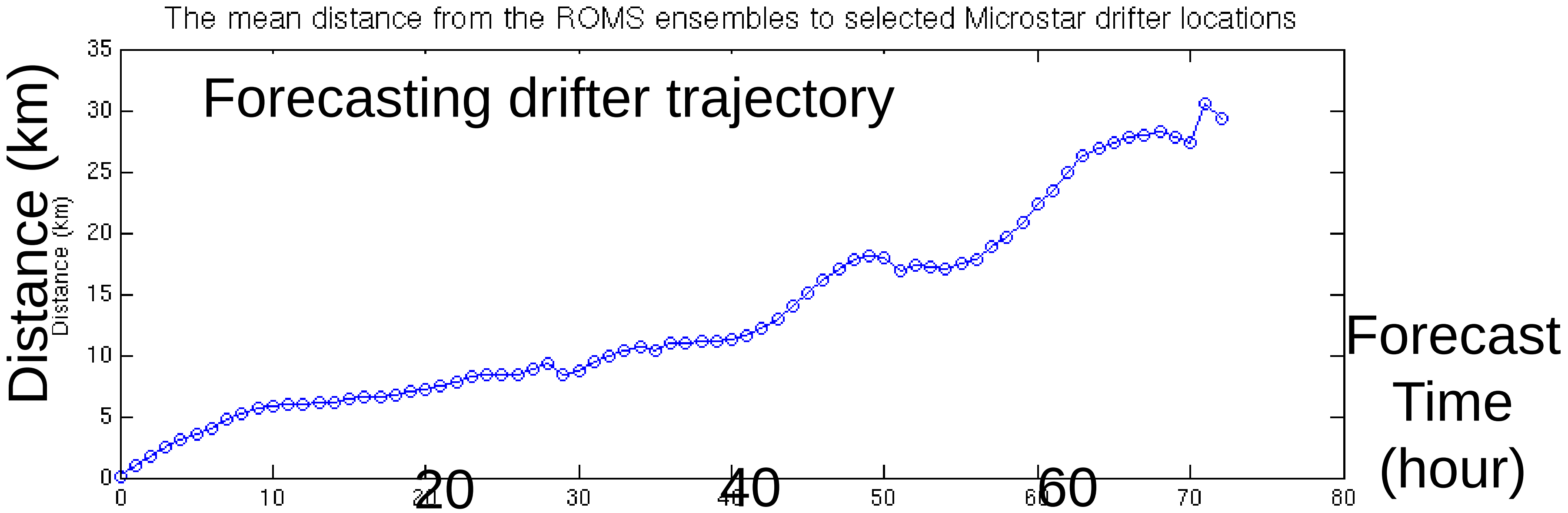


Ensemble Forecast
&
Error Estimation



How is the forecast error growing with time is VERY important





View Nowcast and Forecast

July 2009

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

<< < > >>

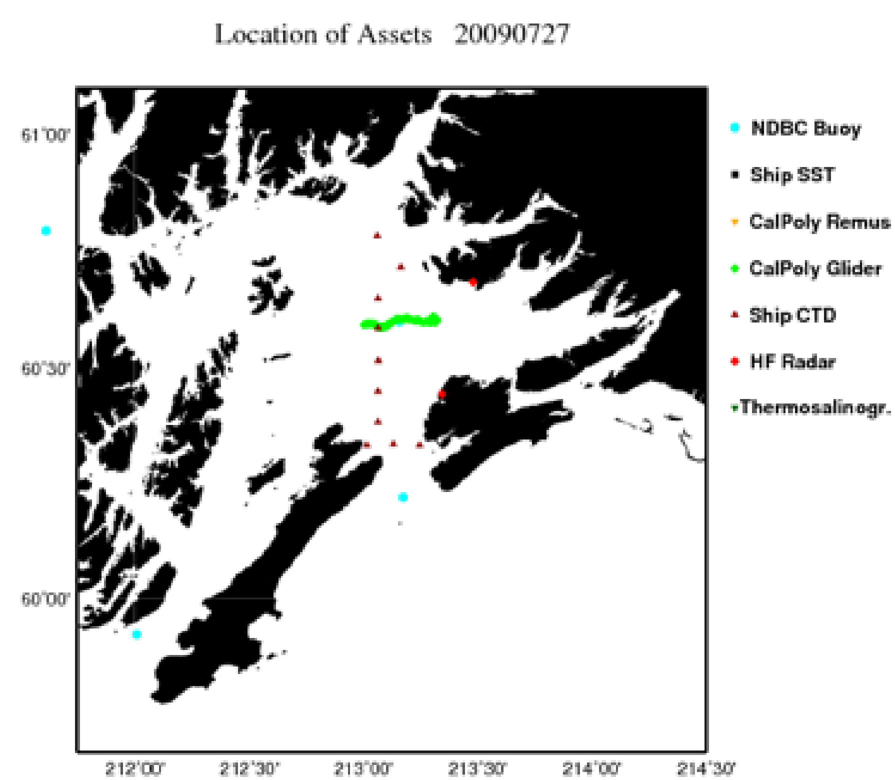
- ROMS Nowcast
  - Temperature
  - Salinity
  - Current
  - Sea Surface Height
- ROMS Forecast
  - 3D Output
- WRF
  - Wind
- ROMS vs. Data
  - Tide Gauge
  - Glider Profile
  - Ship CTD
  - REMUS
  - HF Radar
  - Sea Surface Temperature
- Drifter Trajectory
  - Observation
  - Prediction
  - Ensemble Prediction

Prince William Sound Field Experiment

The JPL OurOcean portal user guide

07/27/2009 - The dominant features on the weather scene today are a high pressure ridge extending northward along the east side of the GOA and a low pressure center rapidly approaching the Alaska Peninsula. Larger-scale forecast models are having difficulty with this low and as a result today's PWS-WRF run was not initialized especially well. In addition, as we enter a period of weaker winds, PWS-WRF is struggling a bit with forecasting wind direction. Winds today have decreased to between 5 and 15 knots over much of the PWS. For the most part, the wind direction continues to be from the east to southeast. PWS-WRF forecasts call for a general continuation of this moderate east to southeast flow through the coming 24 hours, but note that this is a relatively low confidence forecast due to difficulties handling the approaching low pressure center. The flow within much of the PWS as revealed by drifter trajectories and ROMS nowcasts/forecasts continues to be generally northward to northwestward. In addition, ROMS has been suggesting for several days that this flow - which enters through the Hinchinbrook Entrance - has been exiting through the Knight Island Passage/Montague Strait entrance. This flow pattern has been confirmed by recent drifter trajectories, including one released in the Knight Island Passage. The tidal range at all stations continues to slowly decrease from its recent peak. The ROMS ensemble forecast was delayed today, otherwise there were no significant operational issues.

Click here to view a more detailed PWS daily summary.



One-Stop Information Portal

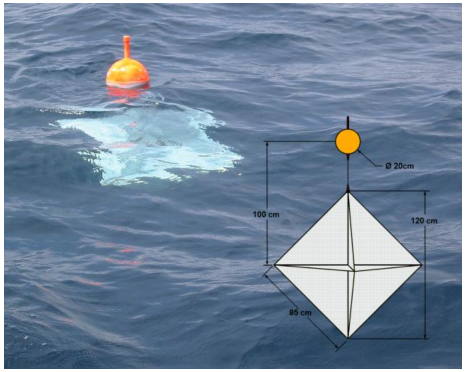
JPL ROMS Analysis & Forecast

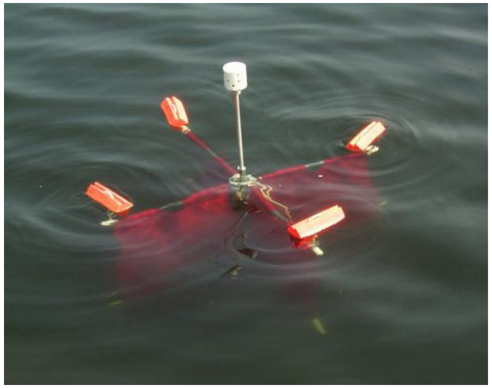
End-to-End Integration for Data and Models

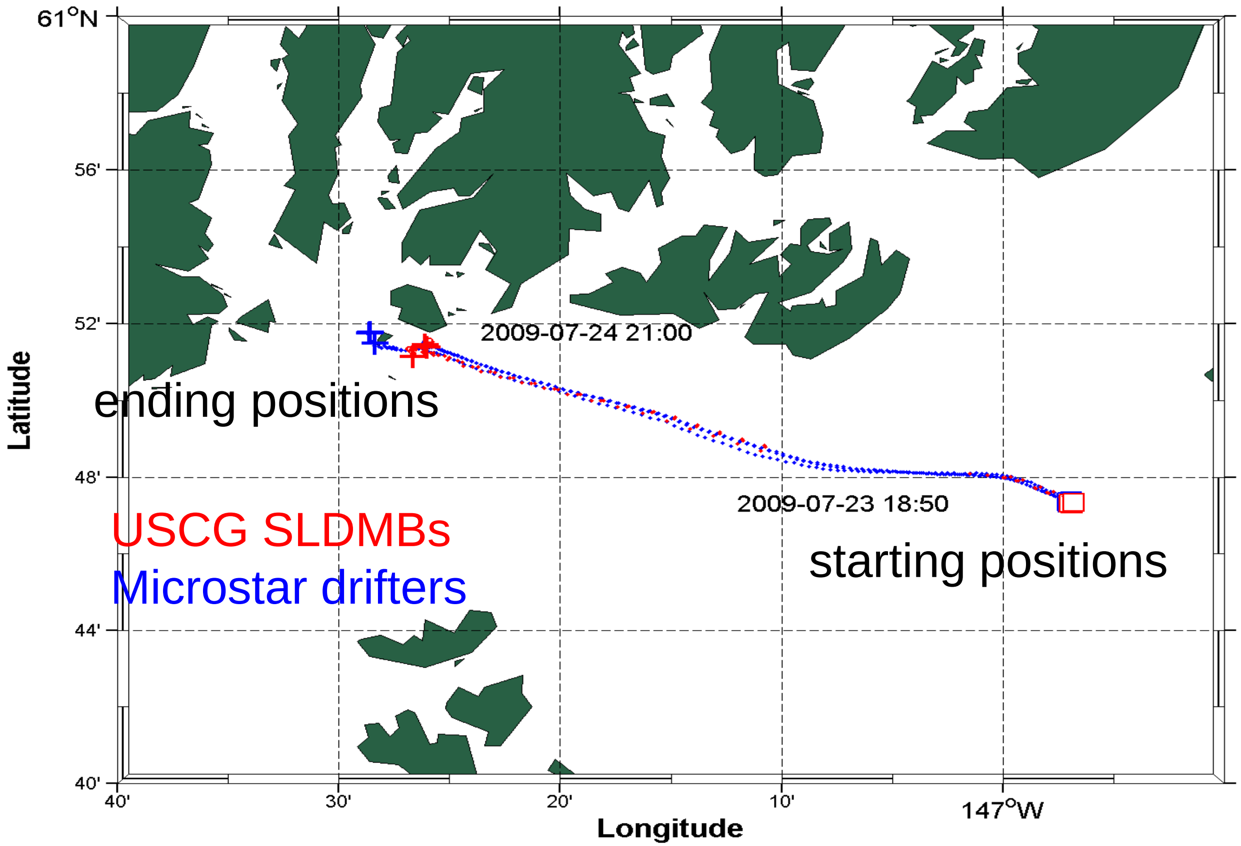
http://ourocean.jpl.nasa.gov/PWS09

Year 2: Component refinement and integration

– Understand uncertainty (two different in situ sensors)



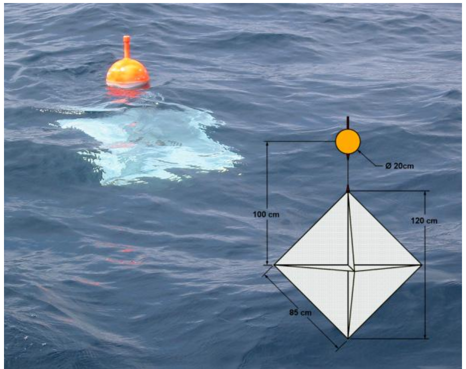


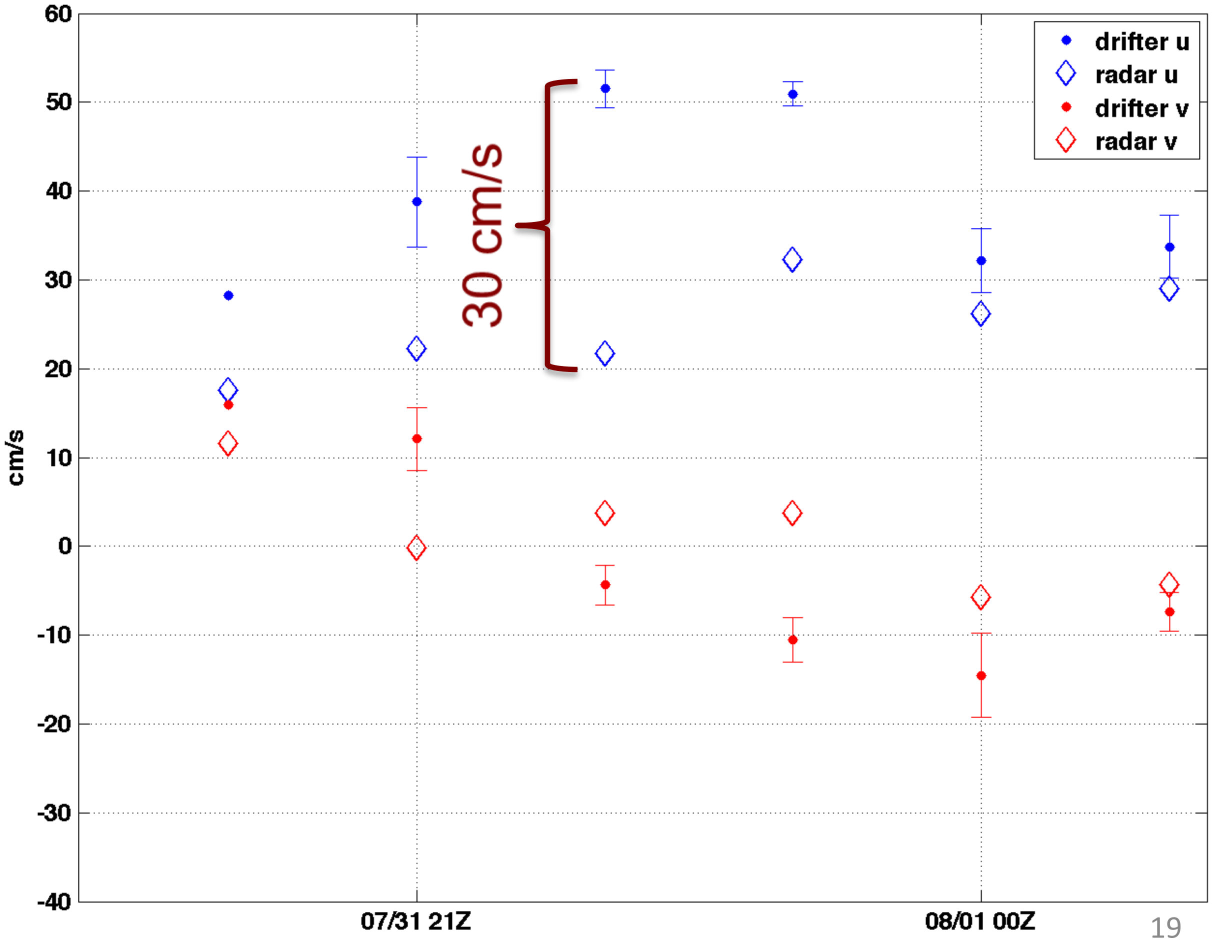


Year 2: Component refinement and integration

– Understand uncertainty

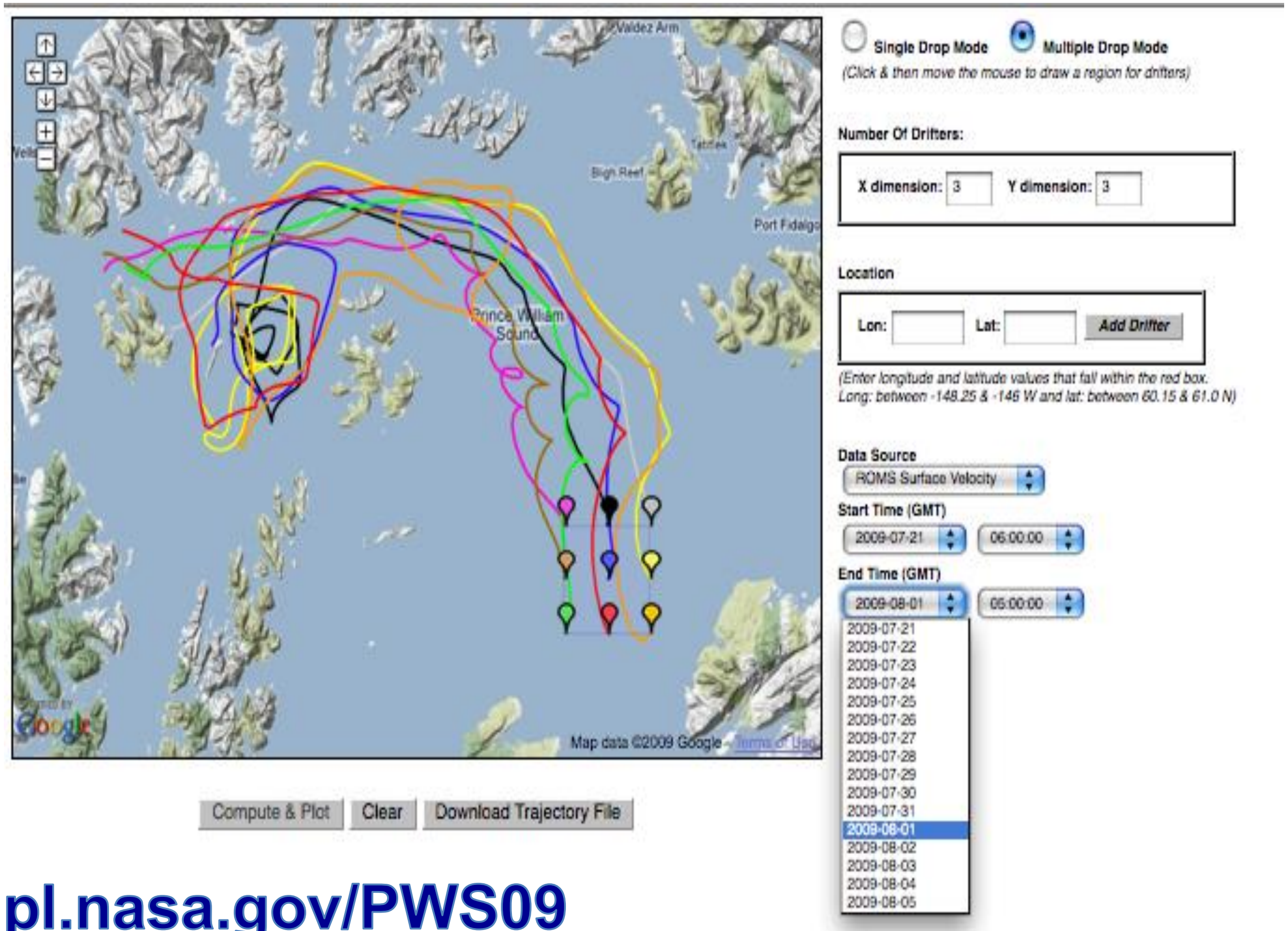
- In situ single-point vs remote sensing averaged measurements





Year 2: Component refinement and integration

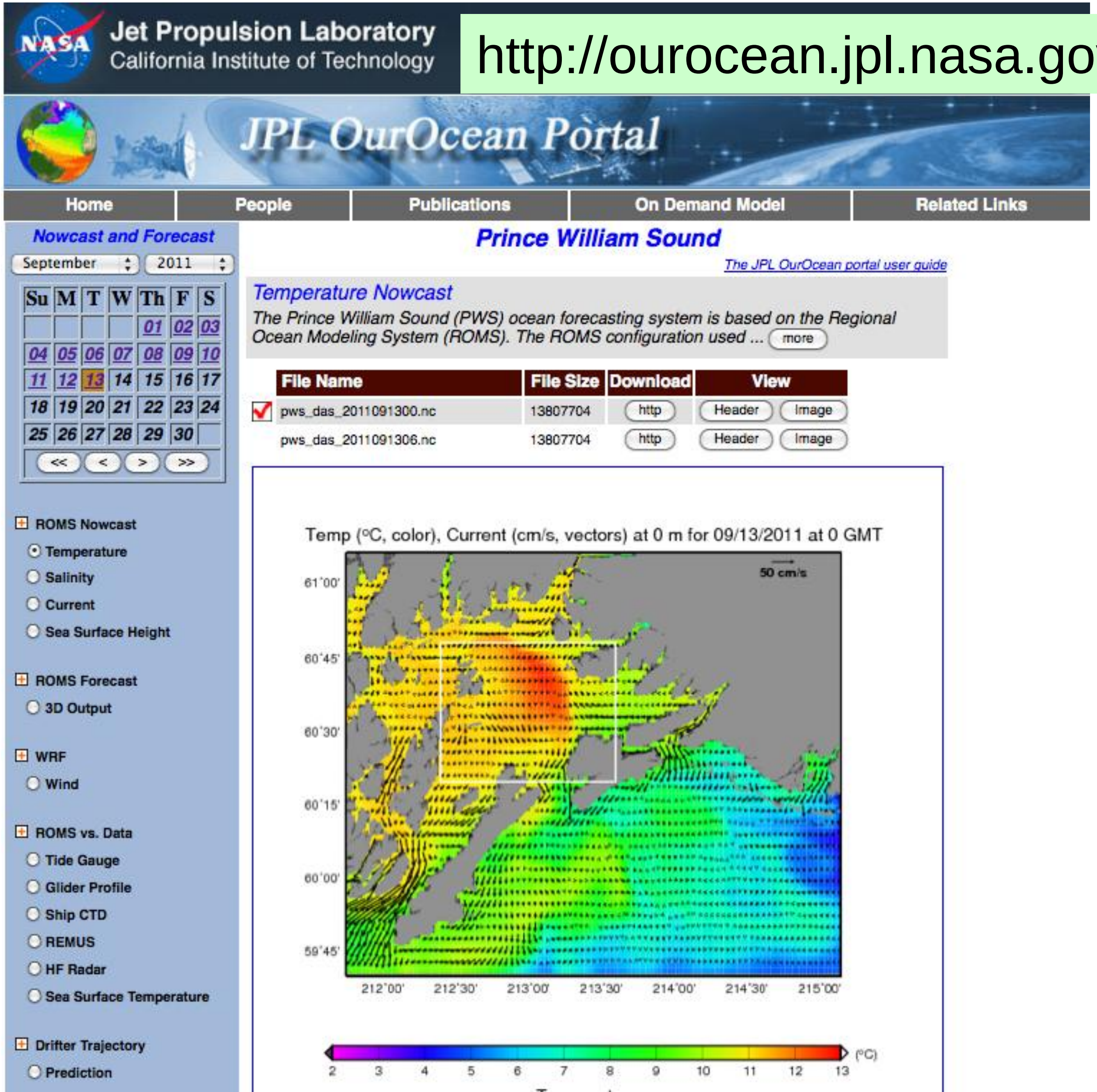
– Understand uncertainty (model spatial variability)



http://ourocean.jpl.nasa.gov/PWS09

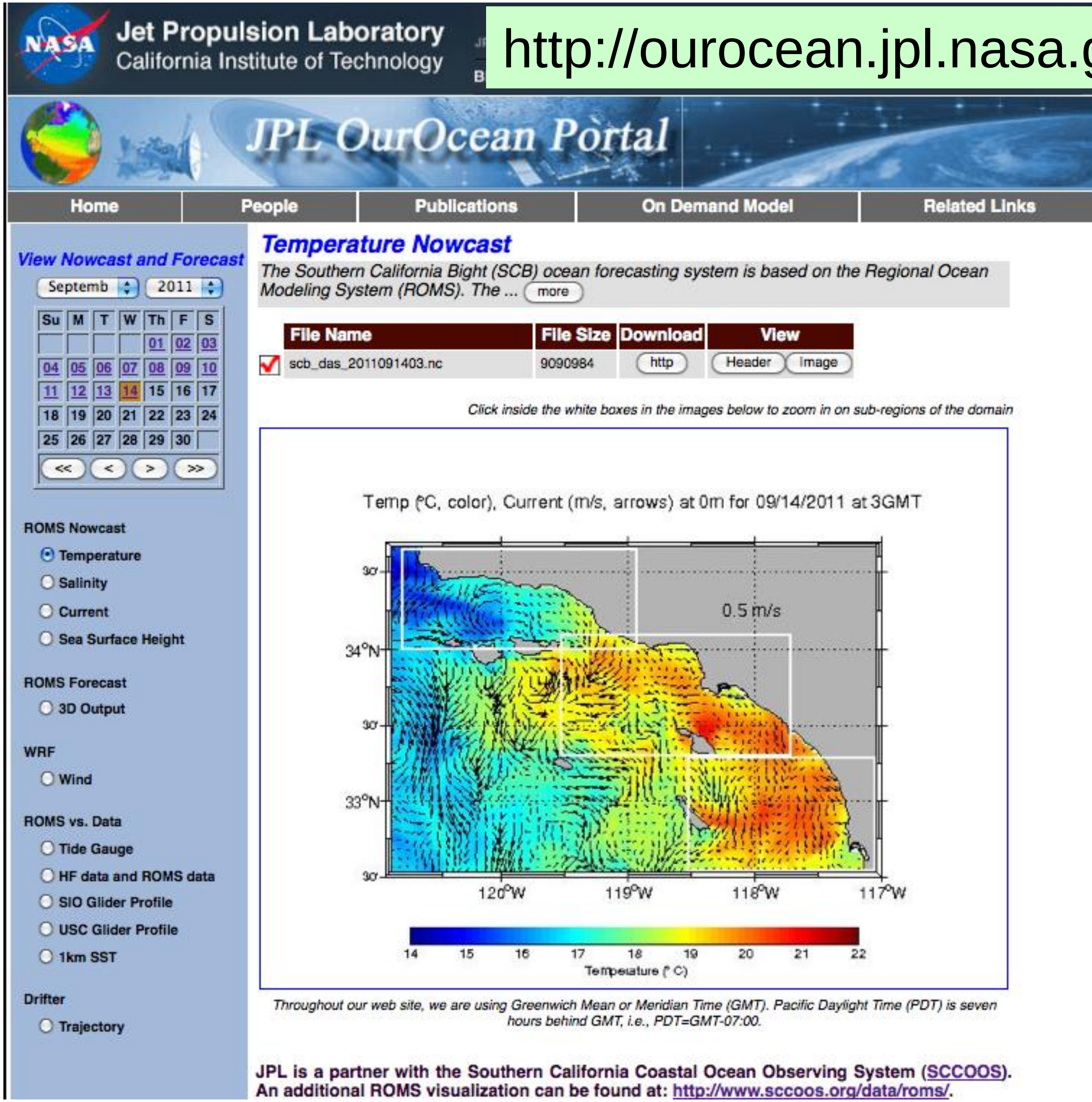
Year 3: Transition from research to operations

http://ourocean.jpl.nasa.gov/PWS/

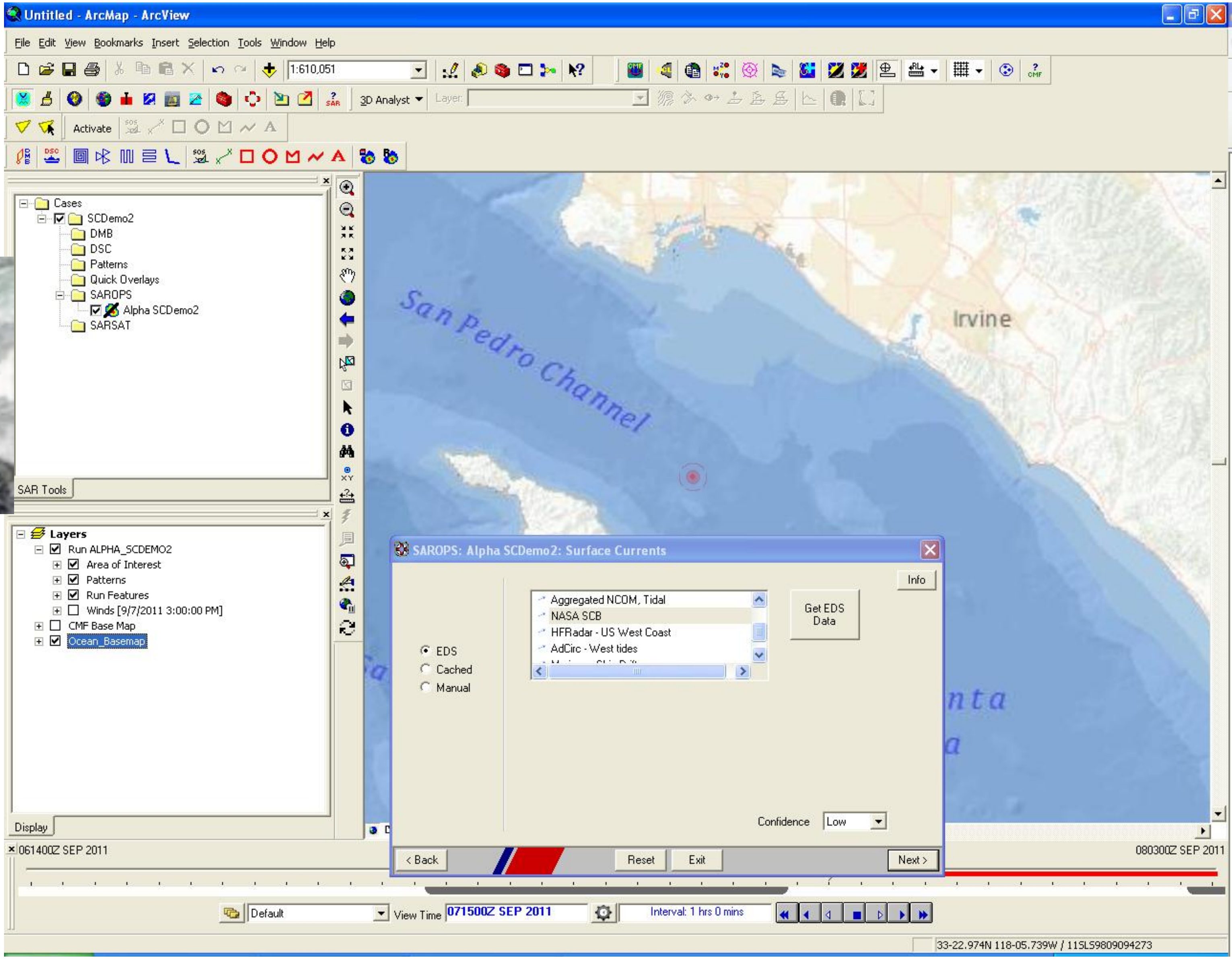


Year 3: Relocating from Alaska to California

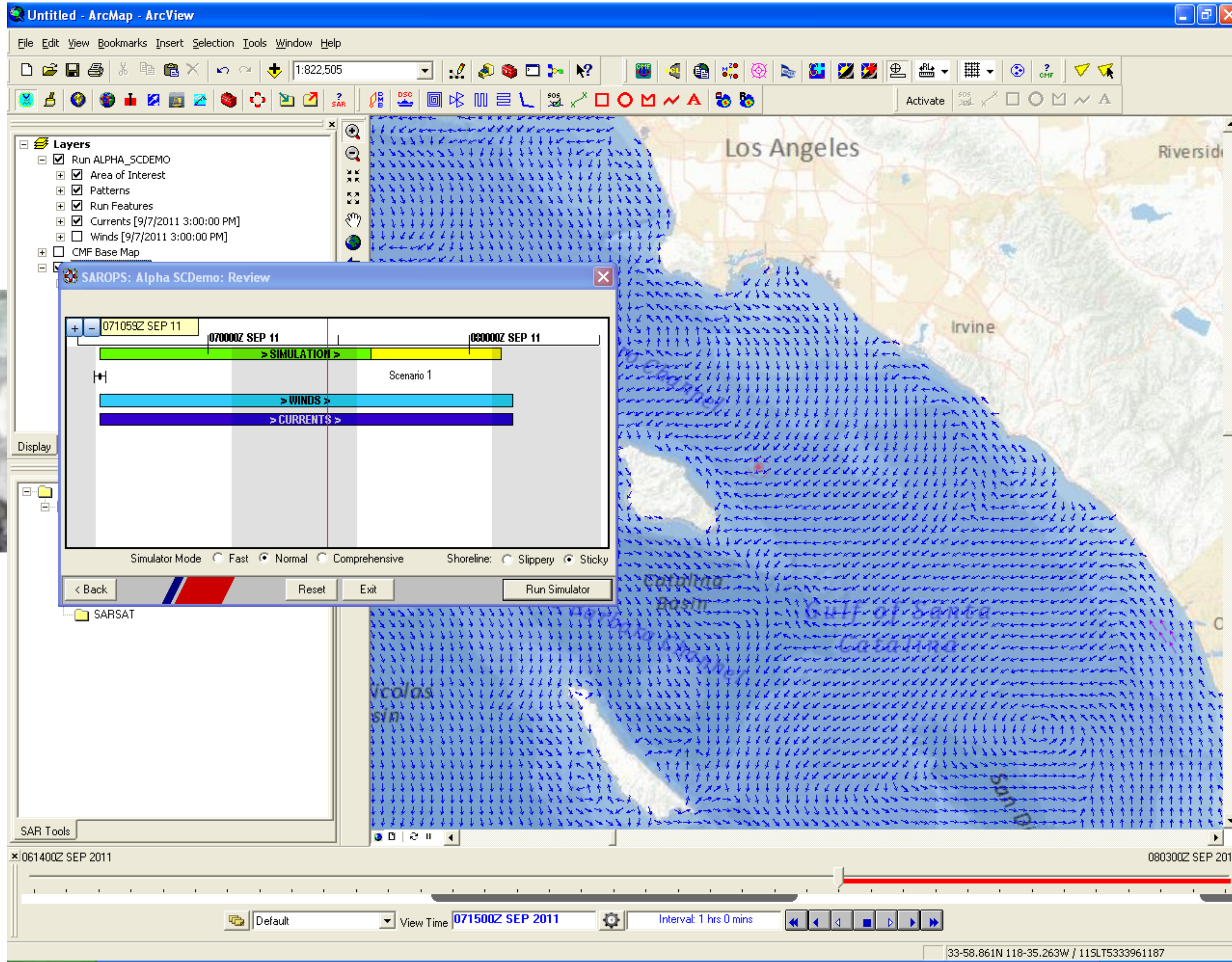
http://ourocean.jpl.nasa.gov/SCB



Year 3: Transition from research to operations

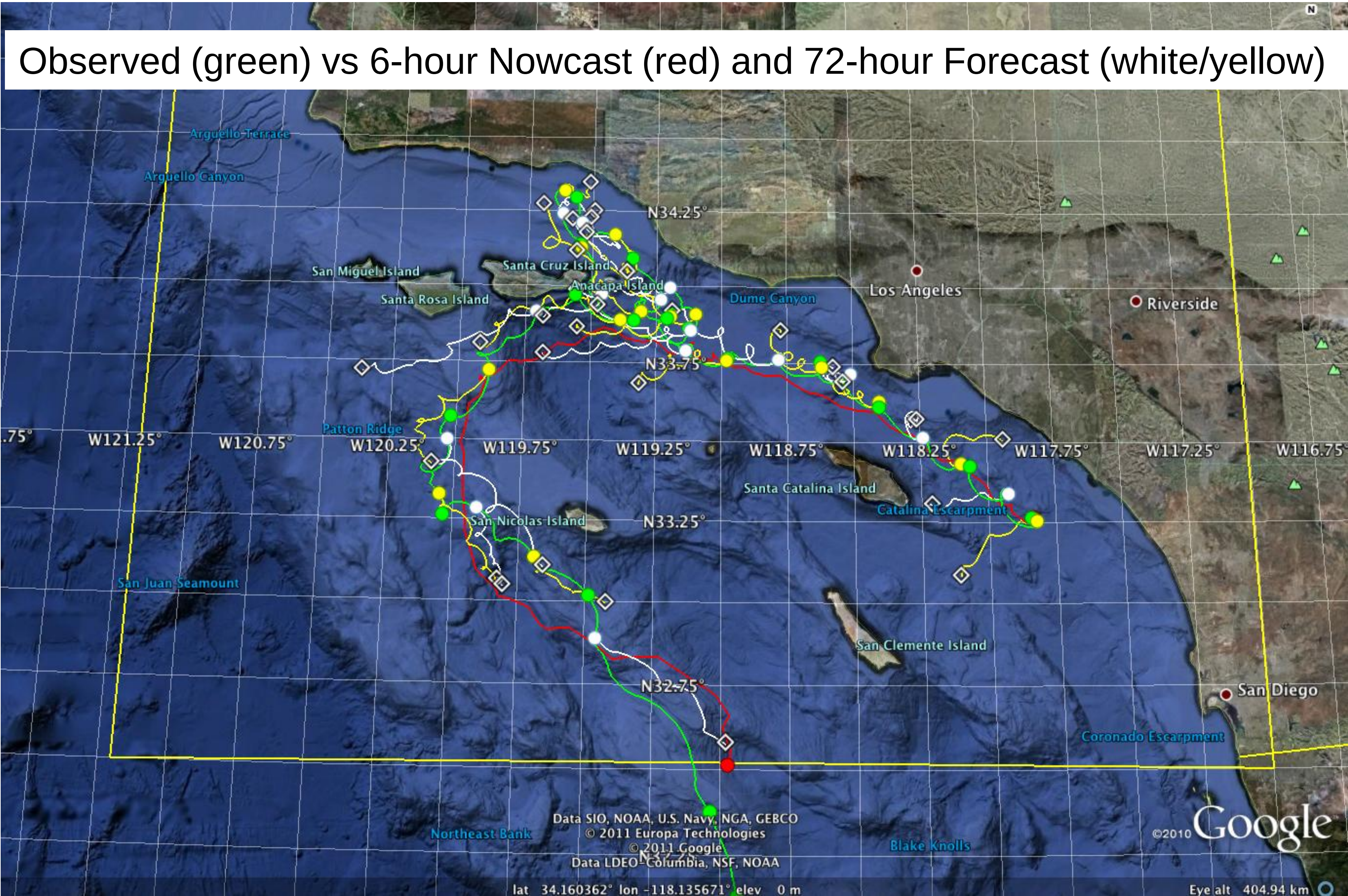


Year 3: Transition from research to operations



Year 3: Quantify the improvement (by USCG)

Observed (green) vs 6-hour Nowcast (red) and 72-hour Forecast (white/yellow)



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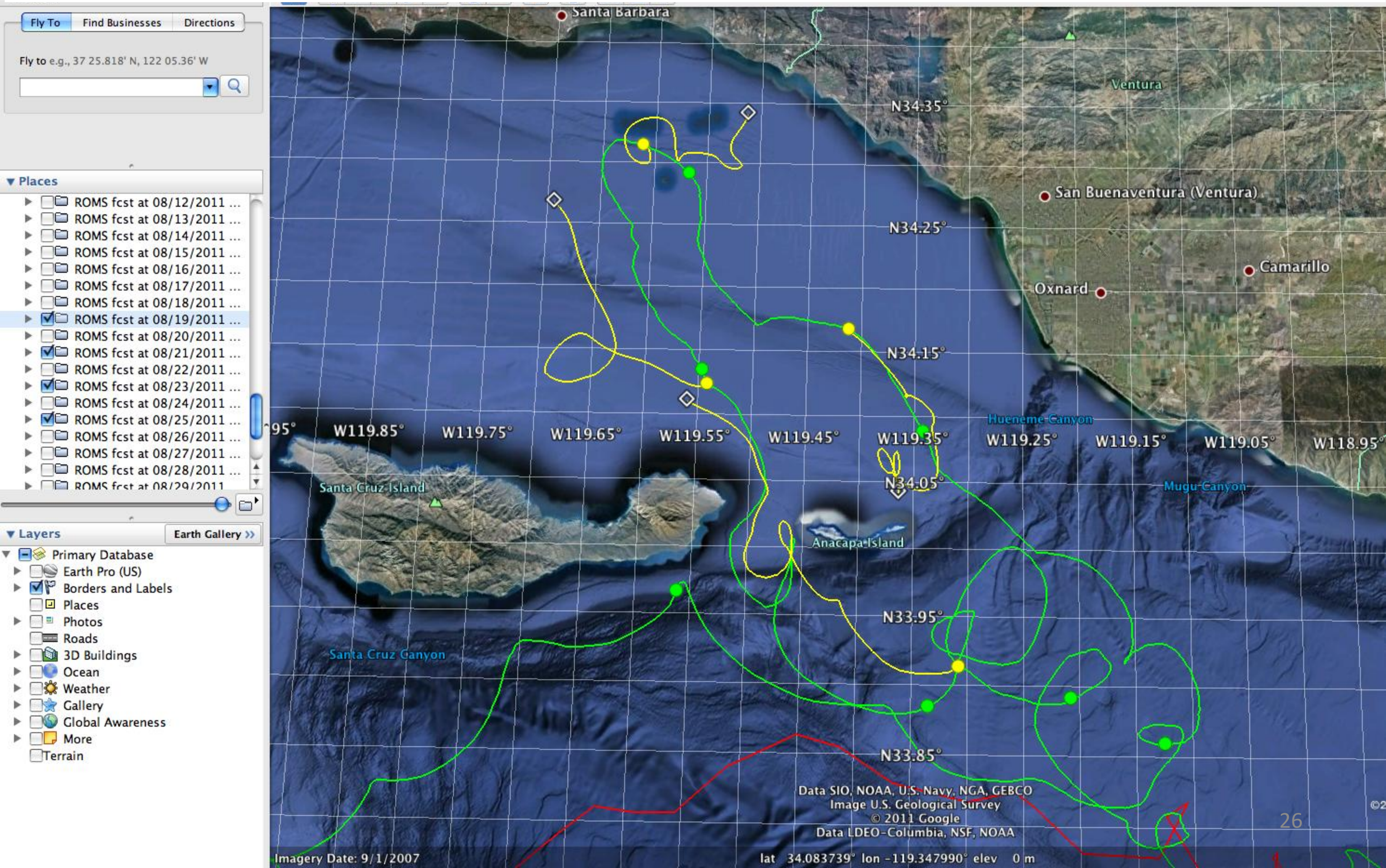

Publications

- Schoch and Yi Chao (2010) Ocean Observing System Demonstrated in Alaska, EOS, Transactions, American Geophysical Union (AGU), Vol. 91, No. 20, 181-182.
- Schoch and Chao et al., An Ocean Observing and Forecasting Experiment in Prince William Sound, Alaska, Bulletin of American Meteorological Society (BAMS), to appear in August 2011.
- Continental Shelf Research (CSR) special issue, with guest editors: Schoch and Chao, manuscripts (~20) in review, final publication early 2012, opportunity for another cover page; NASA contributed about 30%.

AN OCEAN OBSERVING AND PREDICTION EXPERIMENT IN PRINCE WILLIAM SOUND, ALASKA

BY G. CARL SCHOCH, YI CHAO, FRANCOIS COLAS, JOHN FARRARA, MOLLY MCCAMMON, PETER OLSSON, AND GAURAV SINGHAL

Twenty years after the *Exxon Valdez* oil spill in Alaska a unique field experiment demonstrated an integrated ocean observing system with advanced technologies to enable weather, wave, and ocean circulation forecasting.

Systematic weather observations in North America have a long history dating to the eighteenth century and colonial times when the first country-wide weather organization was the U.S. Post Office and Benjamin Franklin was the Post Master General. In the nineteenth century, Matthew Maury of the U.S. Navy pioneered the collection and documentation of ocean weather and currents observed from ships so that mariners could use these data to shorten transoceanic voyages. The proliferation of the telegraph allowed terrestrial weather observations to be centralized, and newspapers distributed weather reports to the public. Technological innovations in the twentieth century, such as satellite imagery, telecommunications, powerful computers to drive numerical simulation models, and meteorological advancements, have provided a better mechanistic understanding of weather phenomena. Today there are thousands of weather stations reporting in near-real time and 10-day weather forecasts are routinely available from public and private sources. However, compared to terrestrial networks, observations from the oceans are limited and forecasts of winds, waves, and ocean currents are not as well developed. The National Oceanic and Atmospheric Administration (NOAA) Integrated Ocean Observing System (IOOS; information online at www.ioos.gov), through regional associations such as the Alaska Ocean Observing System (AOOS; see www.aoos.org), is developing an expansive infrastructure of networked observational platforms and forecast models.

To demonstrate the utility of an ocean observing and forecasting system with diverse practical applications, such as oil spill response, search and rescue,

AFFILIATIONS: SCHOCH—Alaska Ocean Observing System, and Coastwise Services, Anchorage, Alaska; CHAO—Jet Propulsion Laboratory and California Institute of Technology, Pasadena, California, and University of California, Los Angeles, Los Angeles, California; COLAS AND FARRARA—University of California, Los Angeles, Los Angeles, California; MCCAMMON—Alaska Ocean Observing System, Anchorage, Alaska; OLSSON—Alaska Experimental Forecast Facility, University of Alaska, Anchorage, Anchorage, Alaska; SINGHAL—Texas A&M University, College Station, Texas

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The abstract for this article can be found in this issue, following the table of contents.

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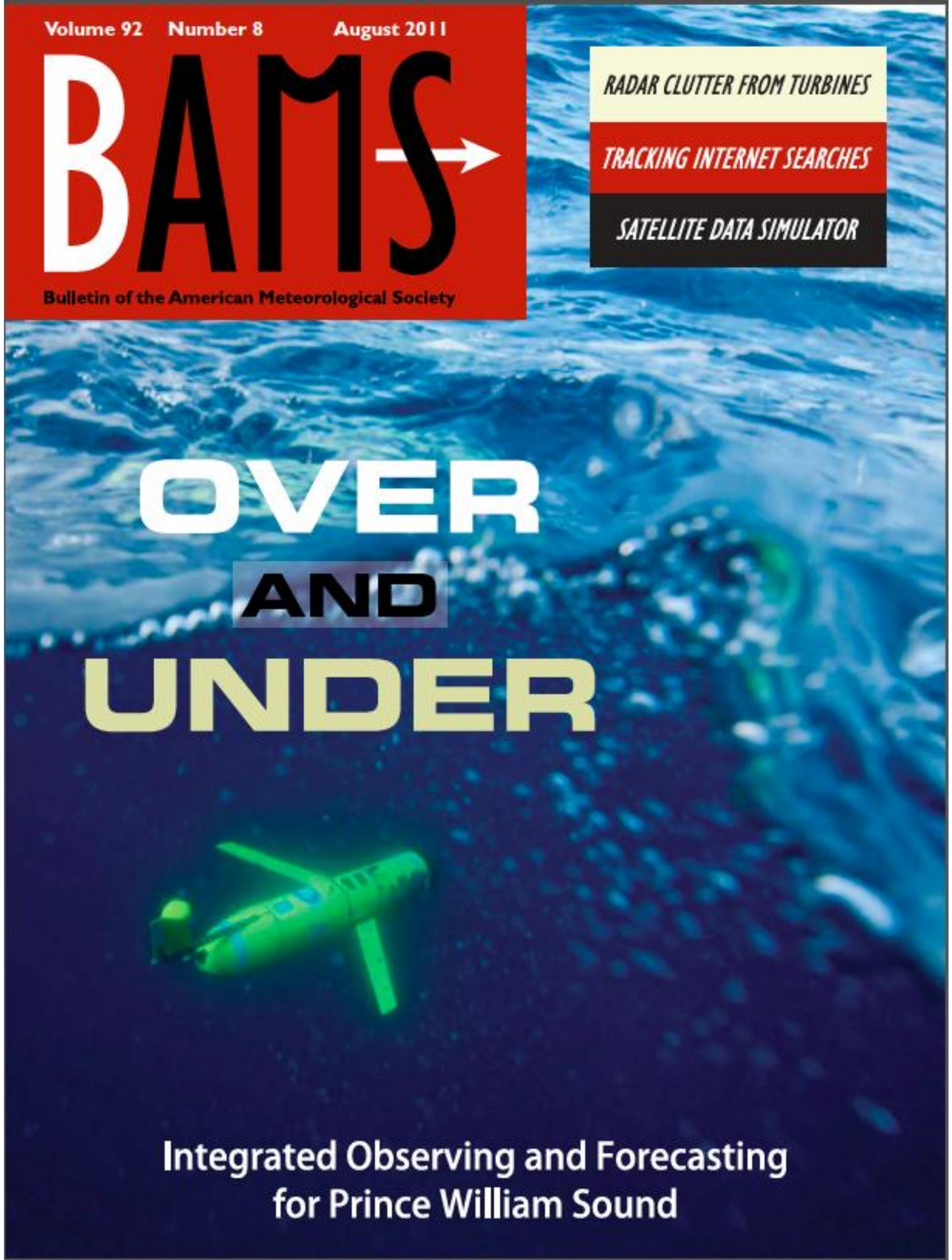
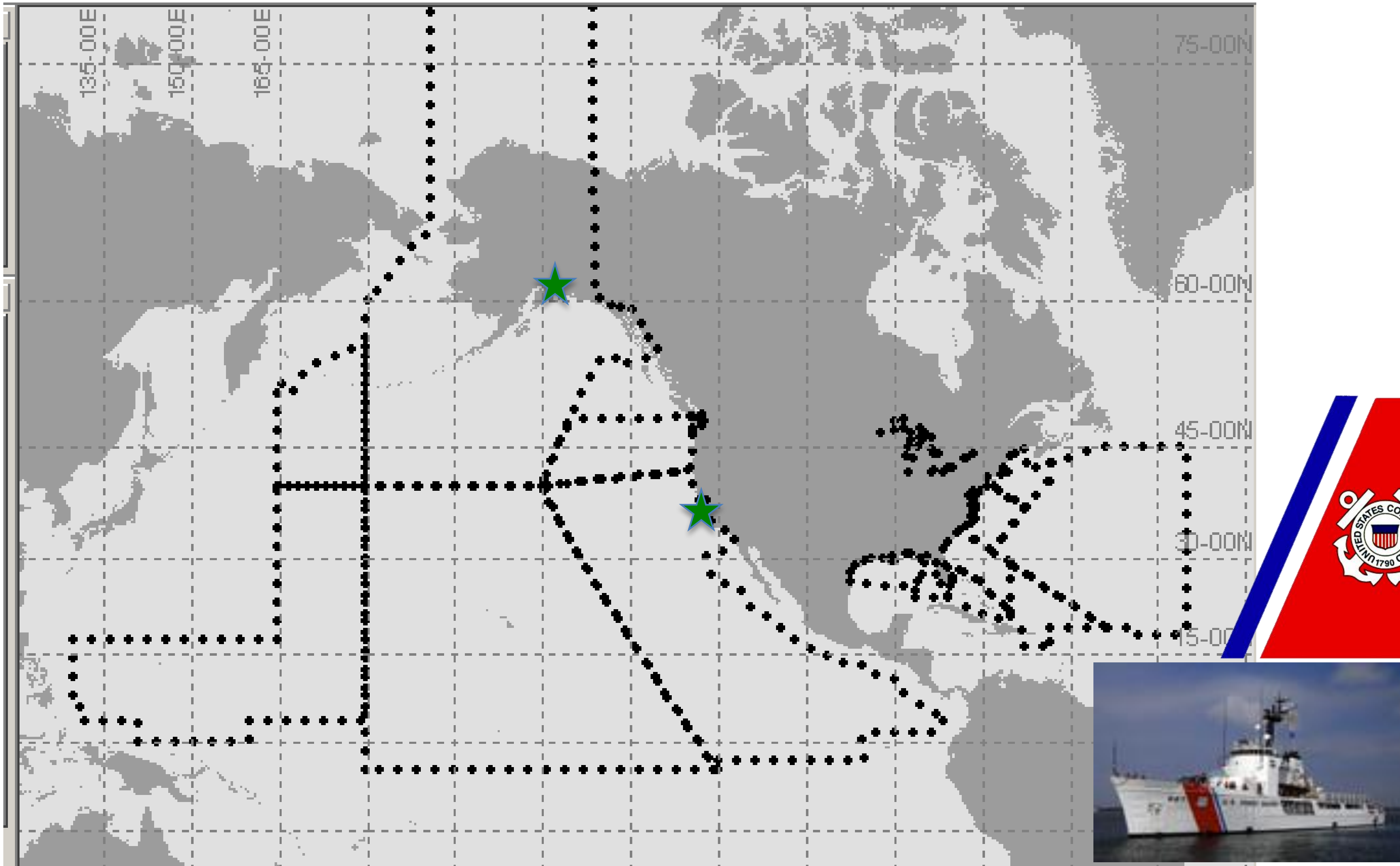


$3K surprise to John!

Future Challenge and Follow-Up Project Idea:

To supply NASA global data and on-demand model forecast in all USCG Search and Rescue areas



Thanks & Questions?

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818-354-8168